

Isotopic Evidence for Spatial and Temporal Changes in Everglades Food Web Structure

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Problem

Food web structure (food web base, number of trophic steps) can influence mercury distribution and bioaccumulation within aquatic food webs. Understanding variations in food web structure over spatial and temporal scales may help explain mercury patterns in Everglades biota.

Background

The nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) isotopic composition of tissues are integrated measures of diet that can be used to distinguish the relative trophic positions of biota.

Laboratory and field studies demonstrate increases in $\delta^{15}\text{N}$ (~2-3‰) and $\delta^{13}\text{C}$ (~0-1‰) between consumers and their diet.

Plots of $\delta^{15}\text{N}$ versus $\delta^{13}\text{C}$ for biota representing a range of trophic positions should therefore show a positive slope (Figure 1).

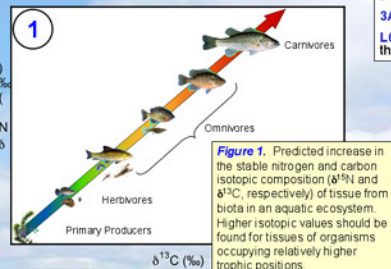


Figure 1. Predicted increase in the stable nitrogen and carbon isotopic composition ($\delta^{15}\text{N}$ and $\delta^{13}\text{C}$, respectively) of tissue from biota in an aquatic ecosystem. Higher isotopic values should be found for tissues of organisms occupying relatively higher trophic positions.

Approach

We investigate three main questions in this study:

✓ Can isotopes resolve relative trophic level differences at the food web scale in the complex Everglades ecosystem?

✓ Does food web structure (as determined by isotopes) vary over space?

✓ Does food web structure vary over time?

Plots of $\delta^{15}\text{N}$ versus $\delta^{13}\text{C}$ for biota tissues are used to identify relative trophic levels. Variations in the $\delta^{15}\text{N}$: $\delta^{13}\text{C}$ slope (or lack thereof) among collection sites and dates are used to address the questions above.

Biota Collections

Plants, invertebrates, and fish were collected from 16 well-studied USGS ACME (Aquatic Cycling of Mercury in the Everglades) sites throughout the Everglades during 1995-1999 as part of a collaboration between the USGS and the Florida Fish and Wildlife Conservation Commission (FWWC).

Within this data set, we focus on biota collected from six sites during several sampling periods when a sufficient number and variety of aquatic organisms were collected (Figure 2).

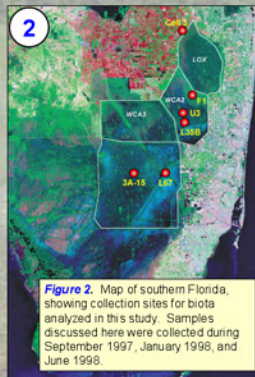


Figure 2. Map of southern Florida, showing collection sites for biota analyzed in this study. Samples discussed here were collected during September 1997, January 1998, and June 1998.

Results: Spatial Differences

Isotope ranges vary by site. $\delta^{15}\text{N}$: $\delta^{13}\text{C}$ patterns also group by site:

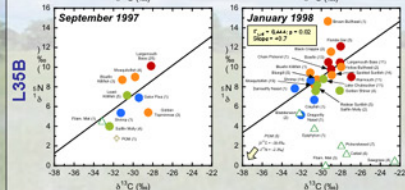
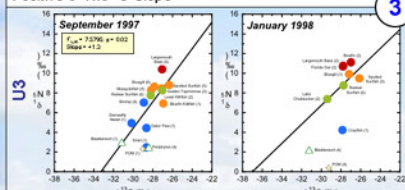
U3 and L35B: Positive $\delta^{15}\text{N}$: $\delta^{13}\text{C}$ slopes ($\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ resolve trophic level differences across the food web (Figure 3).

F1: Negative slopes ($\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ resolve the food web) (Figure 4).

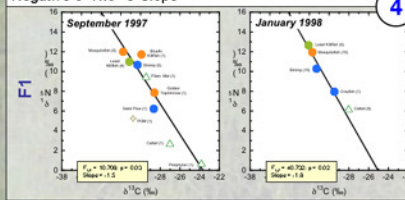
3A-15: No significant slopes (only $\delta^{15}\text{N}$ resolves the food web) (Figure 5).

L67 and Cell 3: No significant slopes (neither isotope adequately resolves the food web) (Figure 6).

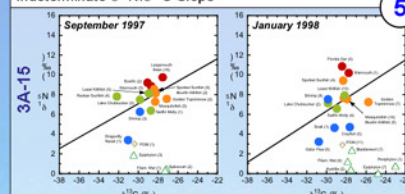
Positive $\delta^{15}\text{N}$: $\delta^{13}\text{C}$ Slope



Negative $\delta^{15}\text{N}$: $\delta^{13}\text{C}$ Slope



Indeterminate $\delta^{15}\text{N}$: $\delta^{13}\text{C}$ Slope



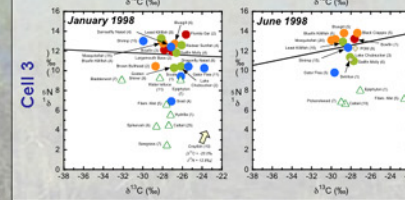
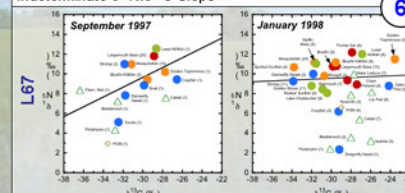
Results: Temporal Differences

Biota $\delta^{15}\text{N}$: $\delta^{13}\text{C}$ patterns also vary by collection date at a given site:

U3 (Sep 1997) and L35B (January 1998) $\delta^{15}\text{N}$: $\delta^{13}\text{C}$ slopes are significant, whereas these sites do not show significant slopes for their other collection dates (Figure 3).

At **3A-15, L67, and Cell 3**, the degree to which $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values show separation among trophic positions varies collection date (Figures 4-6).

Indeterminate $\delta^{15}\text{N}$: $\delta^{13}\text{C}$ Slope



Legend

- Most Carnivorous Fish (fish and decapods)
- Mostly Carnivorous Fish (<25% plants & algae)
- Herbivorous-Omnivorous Fish (>25% plants & algae)
- Invertebrates
- △ Plants & Algae
- △ Particulate Organic Matter & Detritus

✓ Color symbols on the graphs are used here to suggest general trophic groups. The groups are modified slightly from those of Loftus et al. (1998), which were derived based on stomach contents data obtained in the Shark Slough region of Everglades National Park, south of our study area.

✓ Symbols are medians, with the number of separate isotopic analyses shown in parentheses.

Summary

At the food web scale, **nitrogen and carbon isotopes of tissue can discriminate among relative trophic level positions** at some Everglades sites and collection dates, but not well at others. **Isotopic differences among trophic positions vary primarily spatially, but also temporally** for the sites and dates we investigate in this study.

Possibly, spatial and temporal changes in biogeochemical reactions and/or food web base contribute to the different patterns observed here.

Site F1 shows unexpected negative $\delta^{15}\text{N}$: $\delta^{13}\text{C}$ slopes, which contradict expected patterns based on previous laboratory and field studies. One explanation for this pattern is the existence of multiple food webs with different food web bases.

References

Loftus, W.F., Trexler, J.C. and Jones, R.D., 1998. Mercury Transfer Through an Everglades Aquatic Food Web. Final Report, Contract SP-329, Florida Department of Environmental Protection, Homestead, Florida.